

TOTEM STATUS REPORT

Michele Quinto on behalf of TOTEM Collaboration



LHCC OPEN SESSION – March 4, 2015

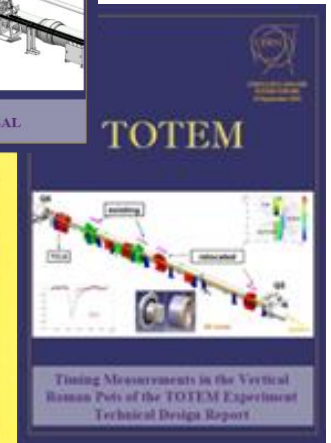
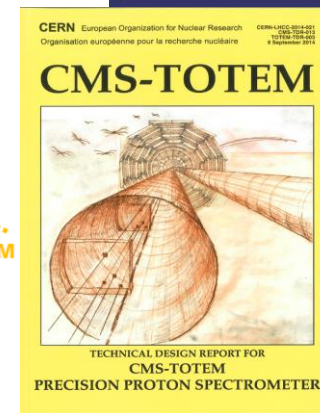
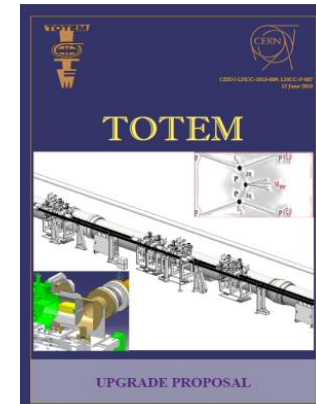
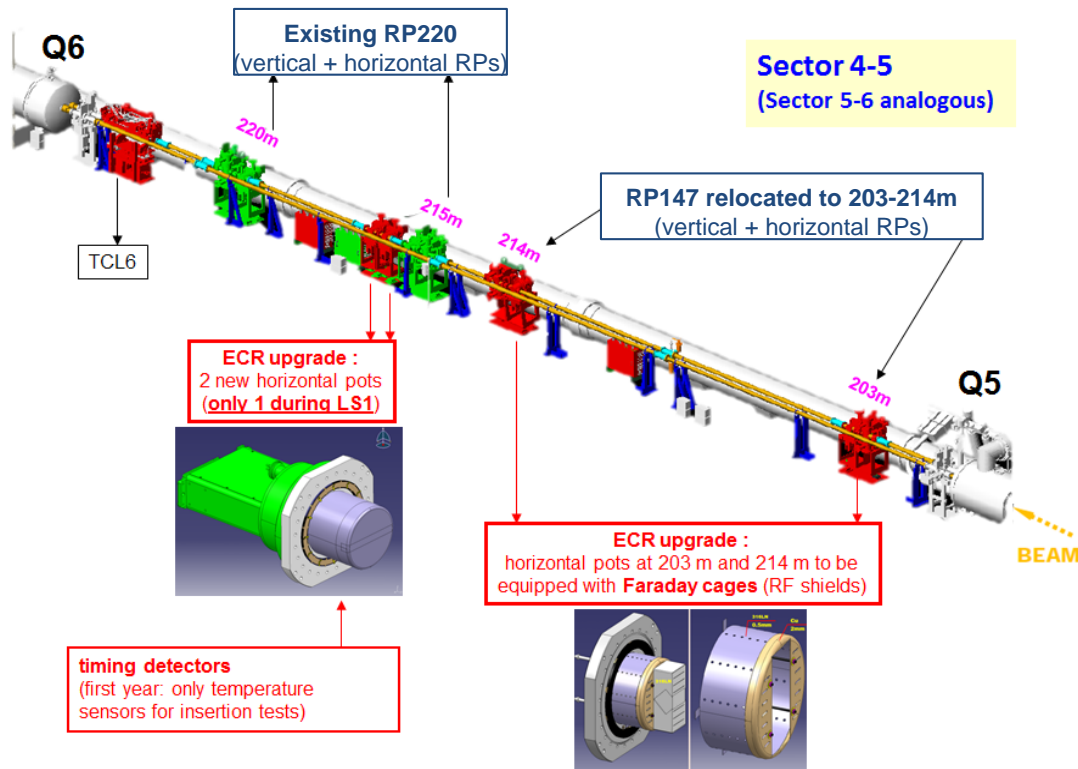


Outlines

- Review of TOTEM's Upgrade & Consolidation program
- TOTEM Readiness for Run Two
- Timing Detector Development
- Test-beams Timeline and Milestones
- Update on CT-PPS
- Publications & Analysis Highlights

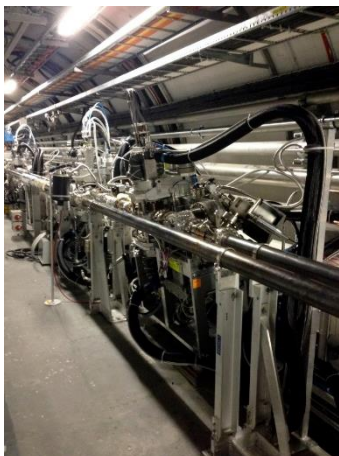
Review of TOTEM's Upgrade & Consolidation program

Upgraded Roman Pot System



Consolidation: Relocate pots at 214m and 203m to improve lever arm and tracking
Upgrade: Installation of cylindrical pots to house future timing detectors and legacy Horizontal Pots with RF shields for CT-PPS

Roman Pot Readiness for Run Two



Oct 2014

Full RP infrastructure
deployed in LHC's
sectors 45&56 – **26
RPs installed!**

Nov 2014

✓ Service lines
connected
✓ Detector packages
installed

Commissioning done

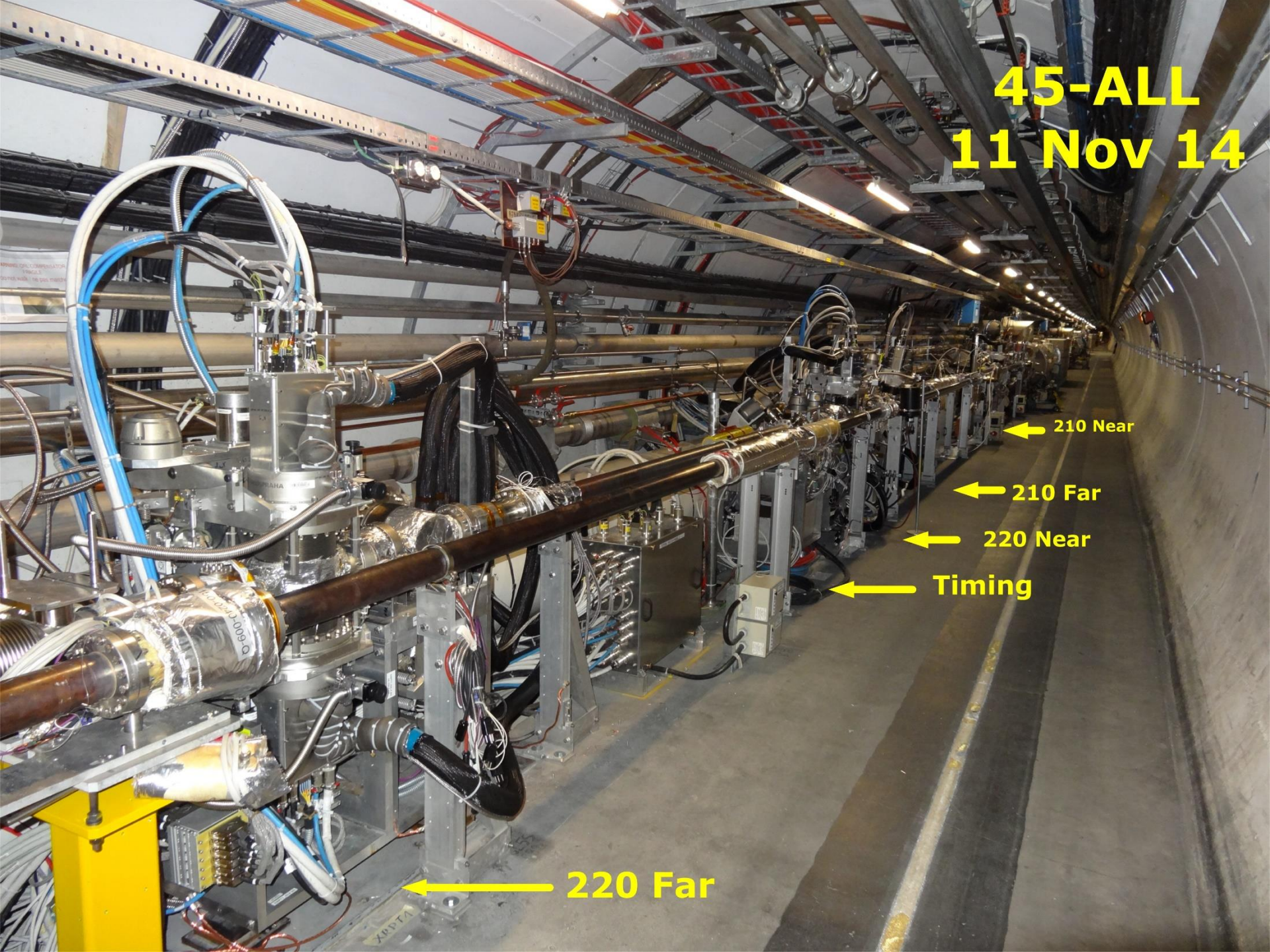
- ✓ Sec. Vacuum & Cooling
- ✓ Powering
- ✓ Control loop
- ✓ RP readout with DAQ
- ✓ Interlock test - started
- ✓ RP movement test from CCC - started

Jan-Feb 2015

Mar 2015

**RPs are on
schedule** expected
to run with the
earliest LHC's beam

45-ALL
11 Nov 14



← **210 Near**

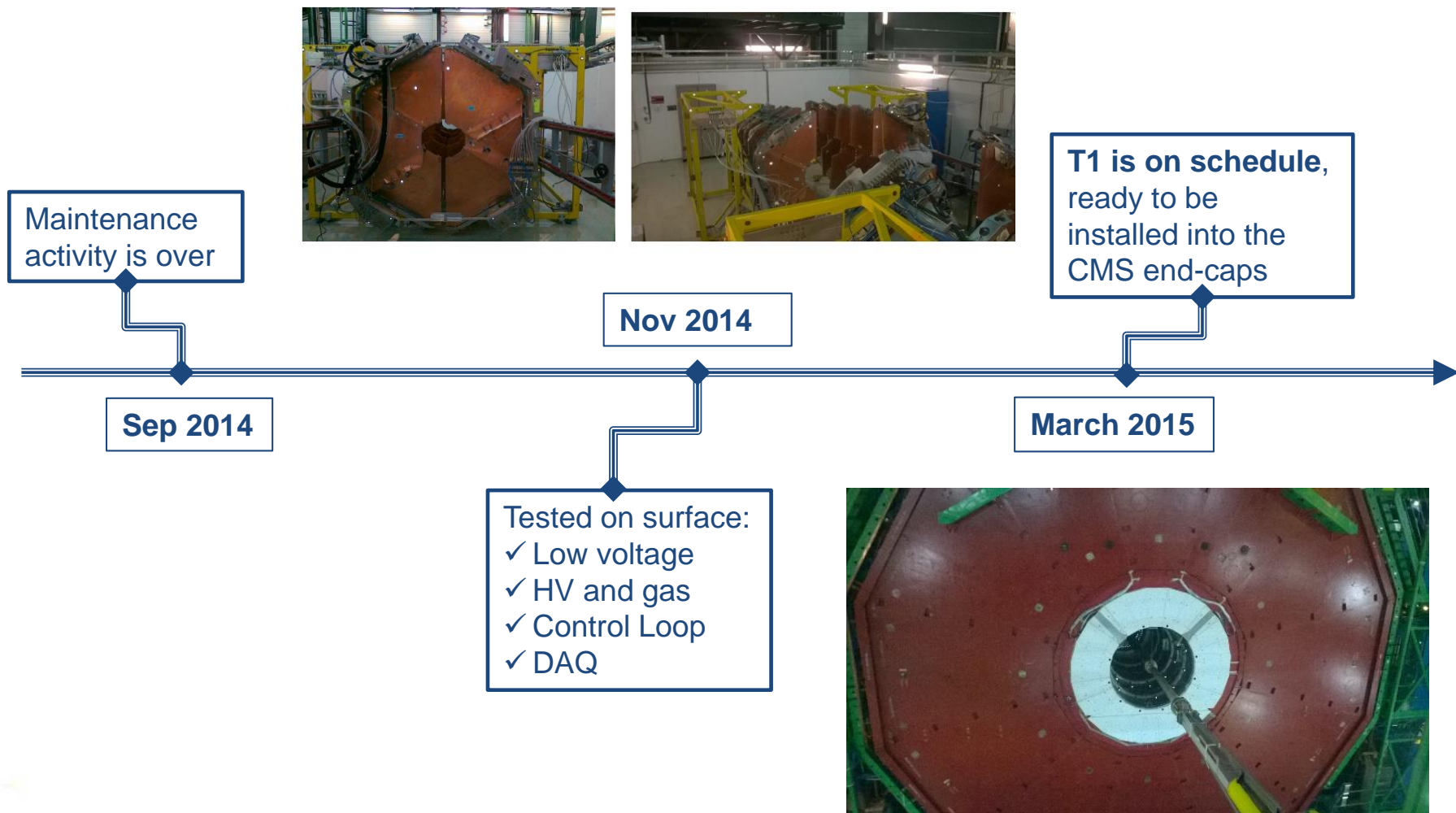
← **210 Far**

← **220 Near**

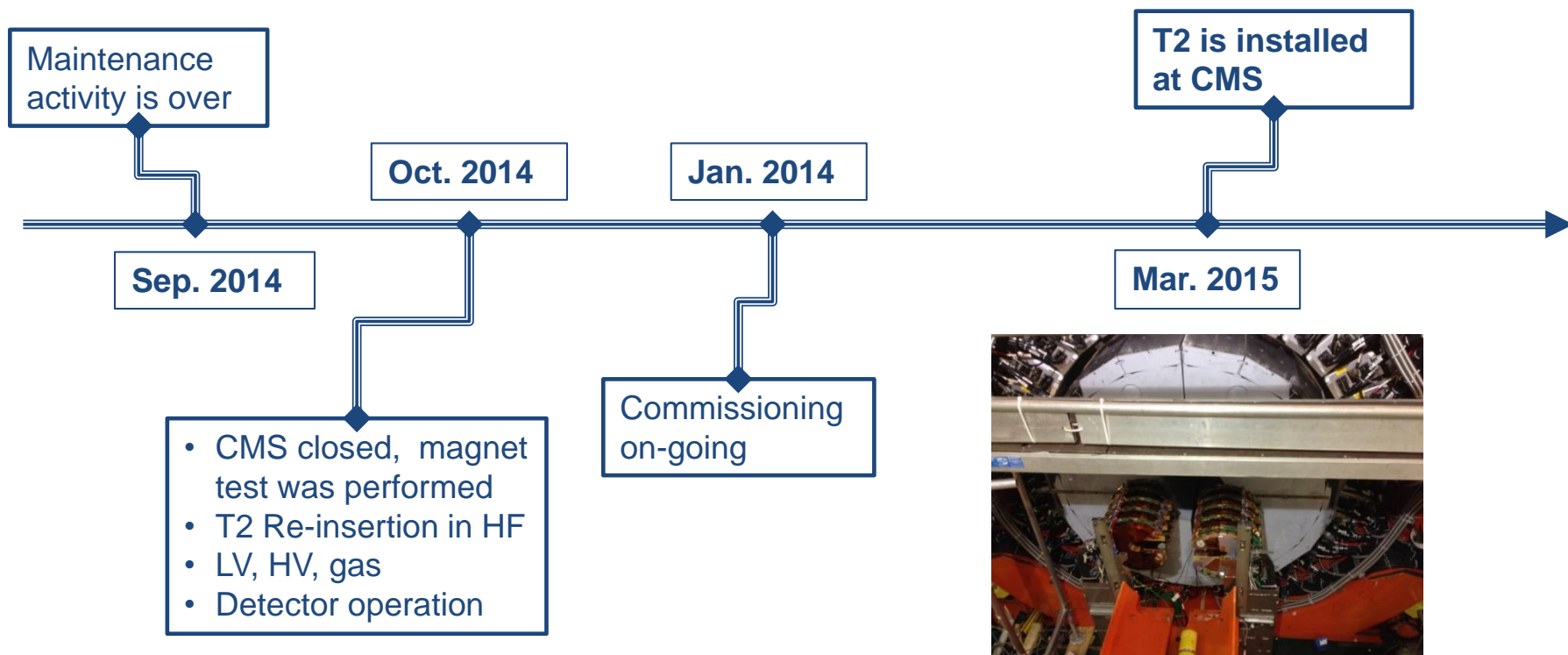
← **Timing**

← **220 Far**

T1 Readiness for Run Two



T2 Readiness for Run Two



- Up to the 11th of Feb T2 was fully checked and functional
- On the 12th due to mechanical stress one quarter was damaged. Due to the tight schedule, to avoid instabilities of the full arm it was decided to exclude the damaged quarter from the control loop
- Impact of having one T2 quarter not operational is less or equal of 1% in all the main Physics channels

DAQ Consolidation

- Replacement of the VME back-end with Ethernet 1Gb links, using RD51 Front-End Concentrator (FEC) cards
- Full compatibility with CMS DAQ and LHC TTC
- Procurement completed
- Commissioning done in the test-bench with real beam reading out the RPs
- 20kHz trigger rate measured: **~20x w.r.t. previous DAQ system**
- Ready for installation in IP5

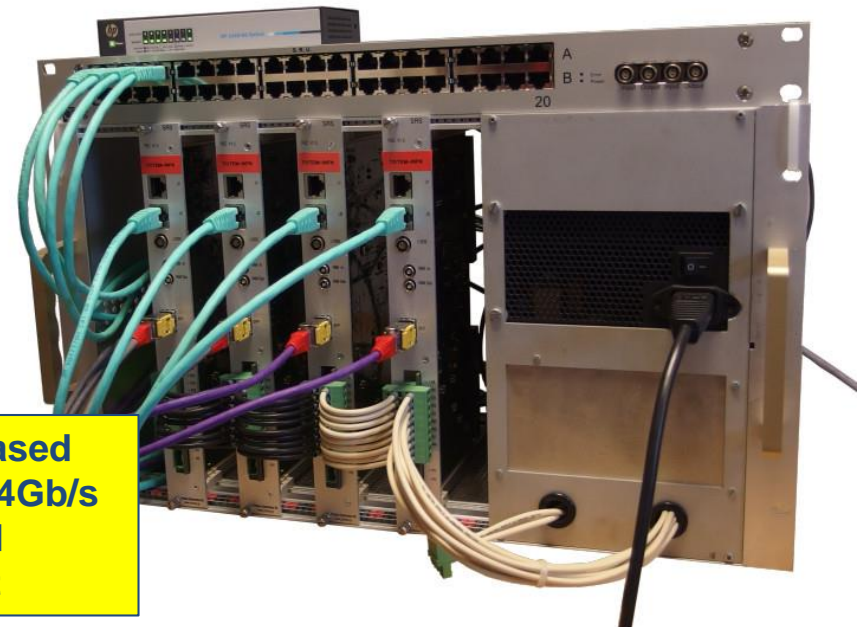


**First
demonstrator
tested in IP5
(Feb. 2013)**

**More details at poster session: Upgrade of the TOTEM DAQ for the LHC's Run Two*

DAQ Future Plans

- Scaling of the full infrastructure of TOTEM stand-alone DAQ
 - Storage space
 - Add computing resources CPUs, FPGAs
- Studies of on-line hardware algorithms:
 - Data-reduction
 - Filtration based on on-line reconstruction
- Further improvements of the DAQ rate capabilities
- Integration with the CMS DAQ



**Ethernet based
DAQ crate 4Gb/s
aggregated
throughput**

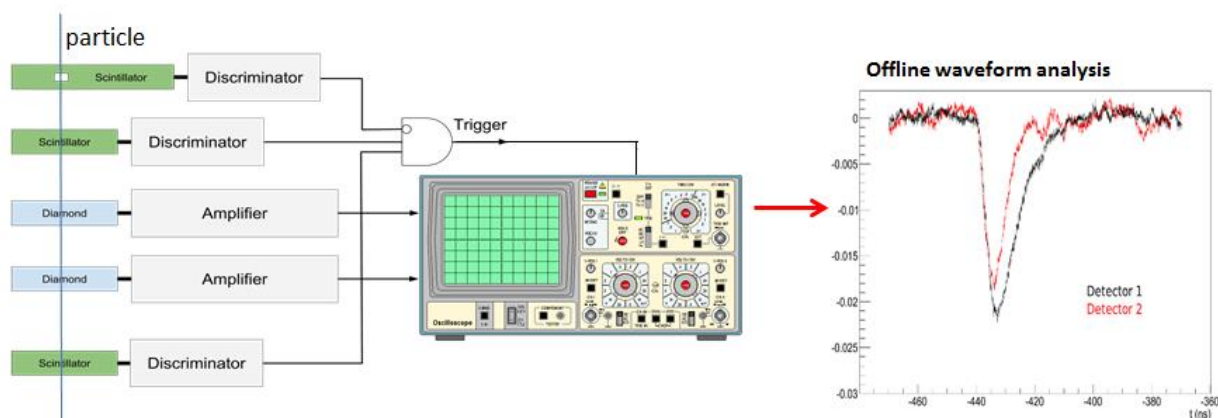
Timing Detector Development for Vertical Roman Pots

Objective:

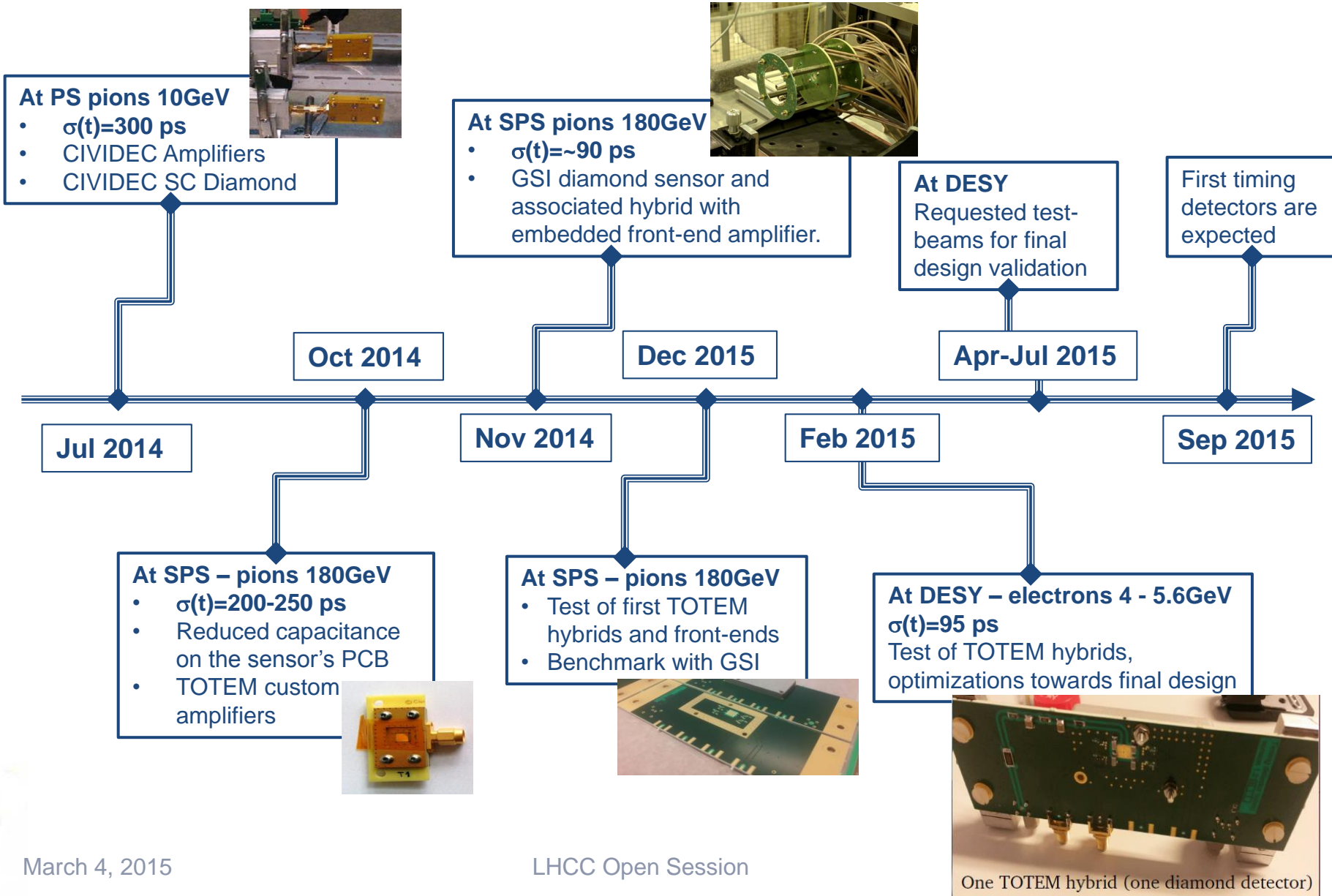
- 4 timing detectors per arm in vertical RPs
- Detector installation foreseen by Sep 2015
- 50 ps resolution per arm (100 ps per detector)

Development:

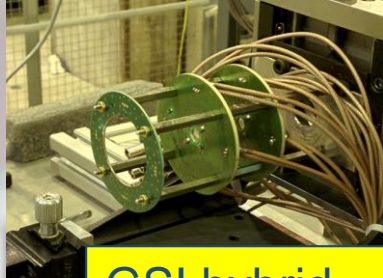
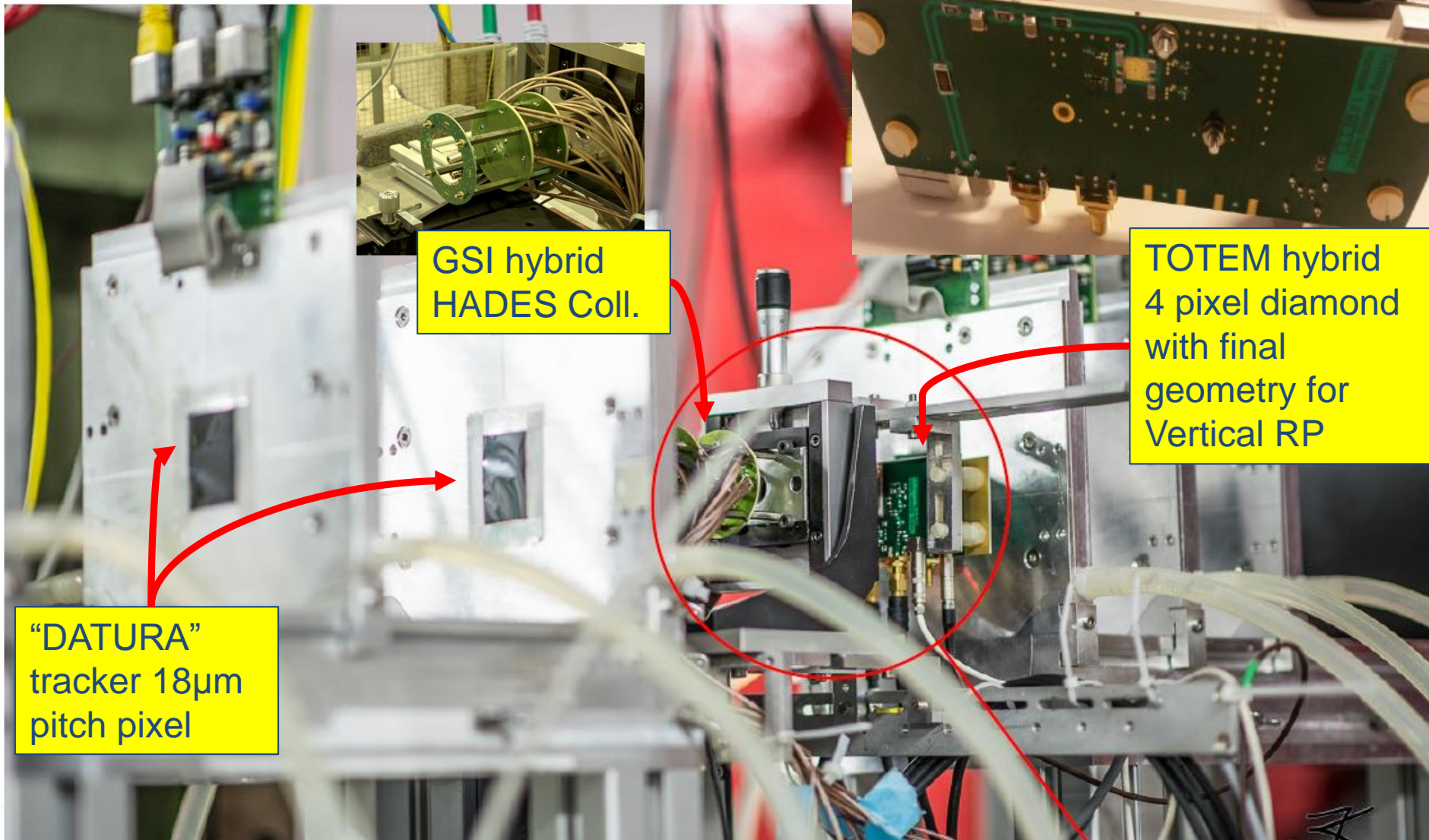
- Intense test beam activity to characterise different detector and front-end configurations (Jul 2014 – Feb 2015).
- Optimization of connection capacitance, front-end amplifier configuration
 - Improve the S/N ratio
 - Improve the rise time
 - Improve the time resolution



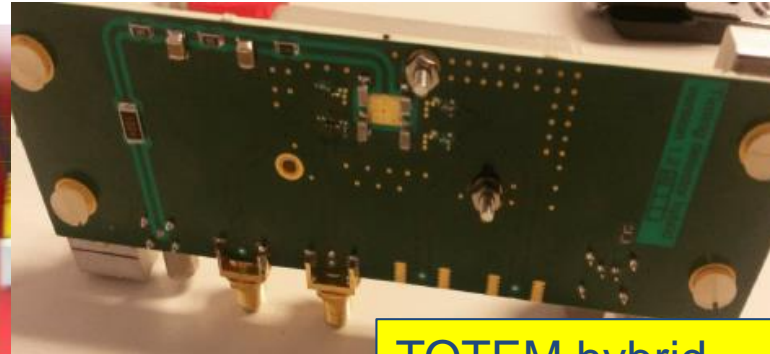
Test-beams Timeline and Milestones



Test-beam at DESY



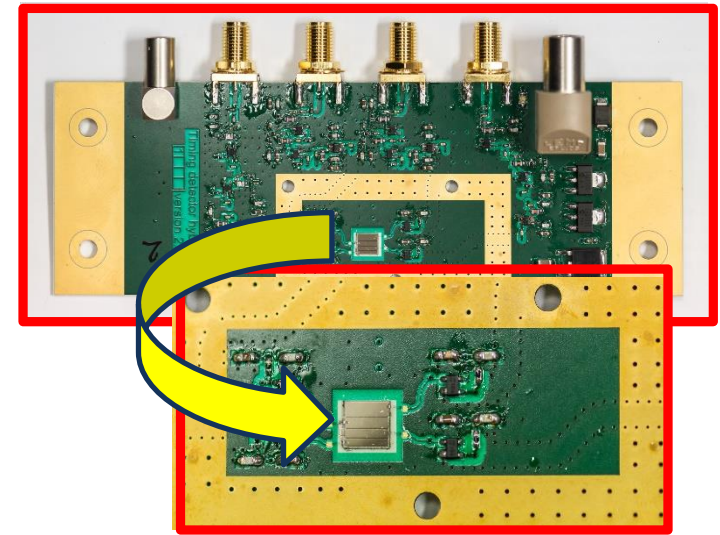
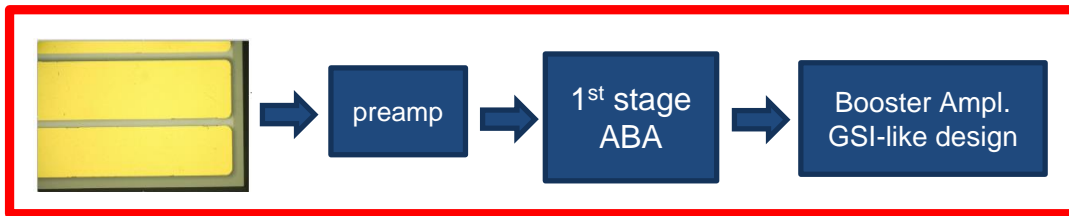
GSI hybrid
HADES Coll.



TOTEM hybrid
4 pixel diamond
with final
geometry for
Vertical RP

“DATURA”
tracker 18 μ m
pitch pixel

TOTEM Hybrid

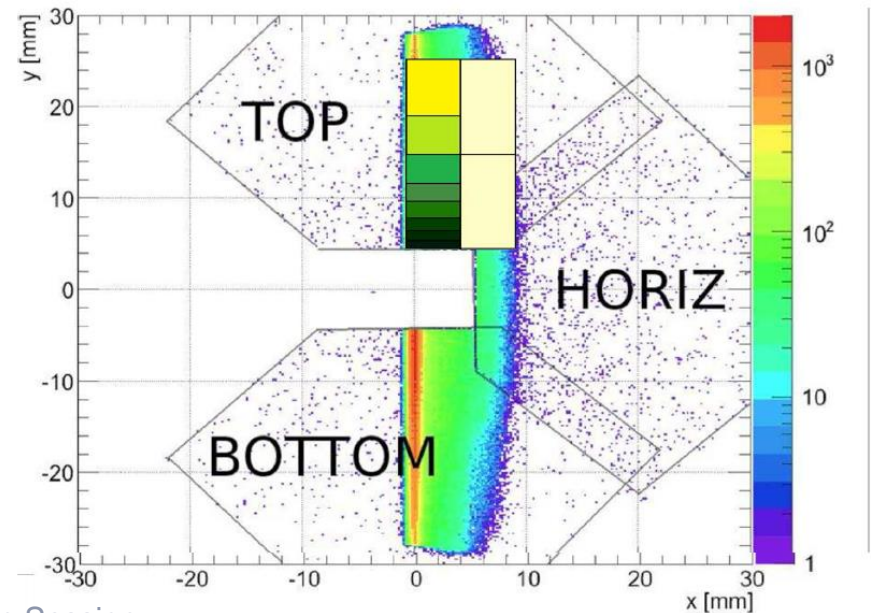


Pixel metallization from GSI:

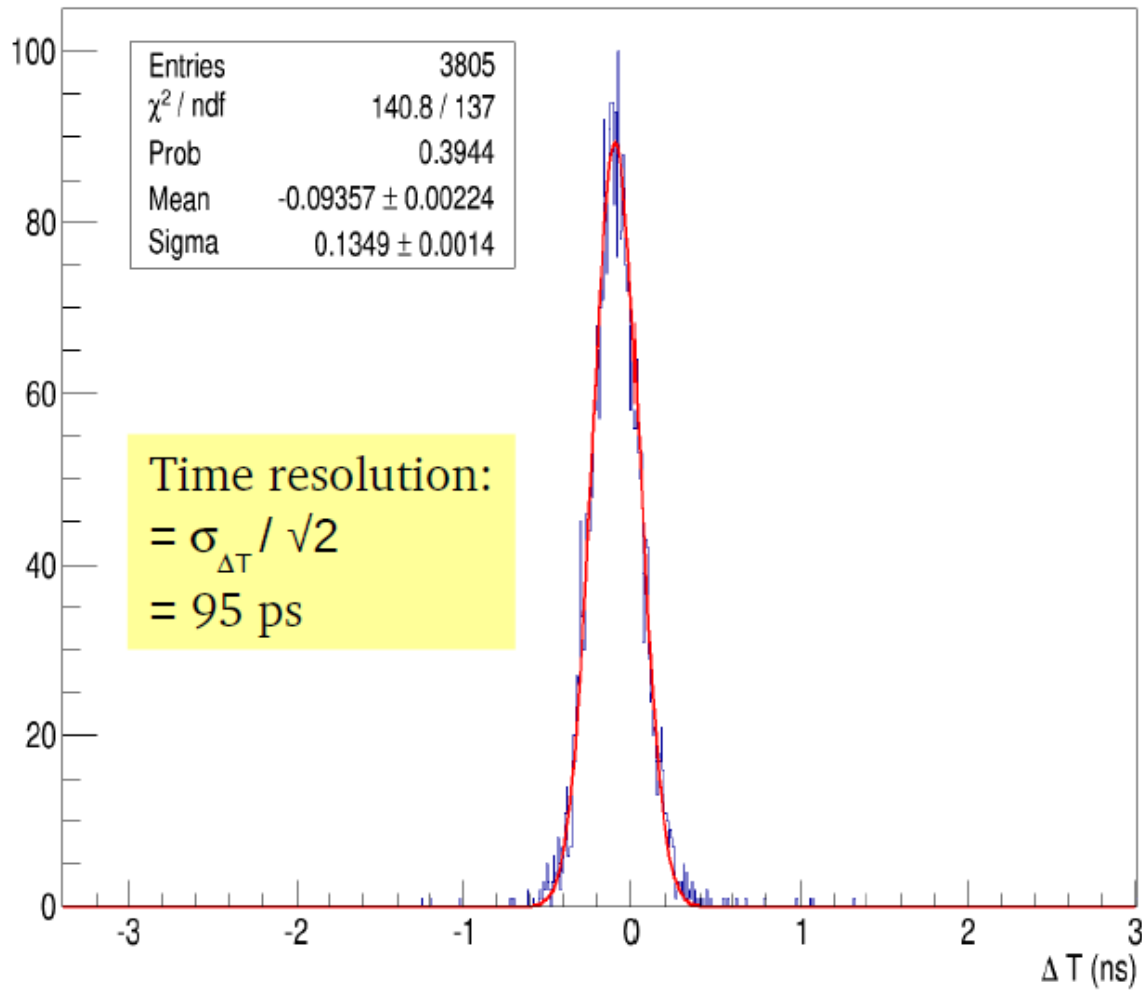
- Hybrid1 - 1 pixel with $C \sim 2\text{pF}$ (largest pixel foreseen in TOTEM)
- Hybrid2 - 4 pixel with $C \sim 0.2\text{pF}$ to $\sim 0.6\text{pF}$

Amplifier by TOTEM based on GSI design

We can test the final pixel geometry foreseen in TOTEM



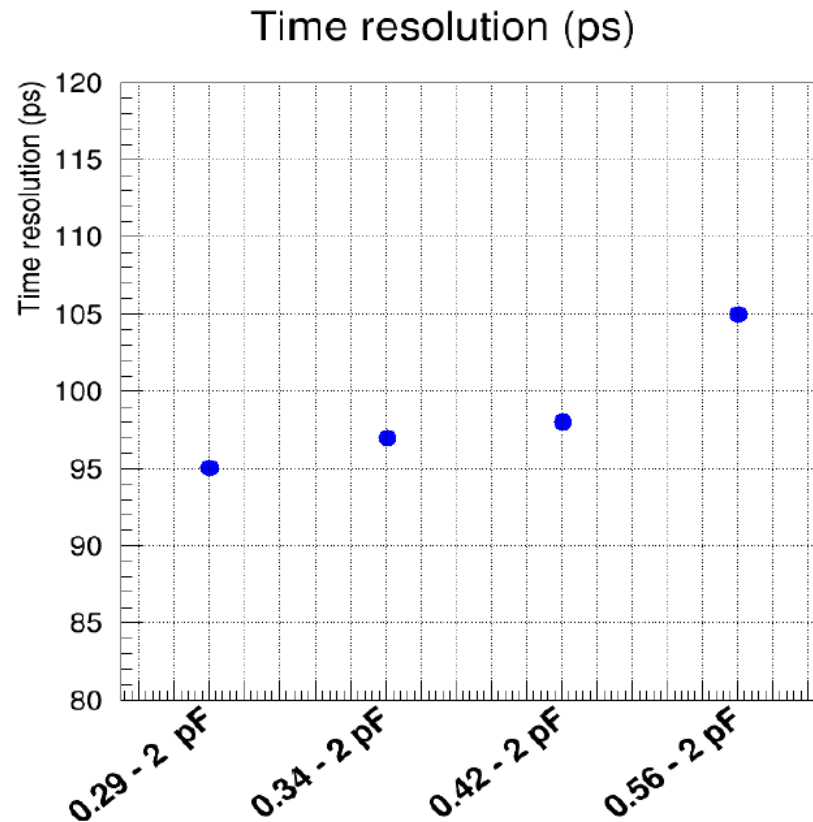
Time Resolution



Time resolution (ps)

Time difference measured between Det1 (C = 2pF) and Det2 (C = 0.29pF)

Time Resolution vs. Pixel Size & Efficiency



- Diamond bulk efficiency calculated for the first time: **>98%**
- More exercises and a better set-up are needed to measure the overall efficiency taking into account pixel geometry (dead zone between pixels)

Update on CT- PPS: Components installed in tunnel

**CT-PPS
timing**

**TOTEM
tracking**

**CT-PPS
tracking 2**

**CT-PPS
tracking 1**

TCL 4 & TCL 6 in 4-5 and 5-6

Electrical patch panel

Service lines for LV/HV/DAQ

CT-PPS specific:

- 2 * RP box with RF shield in 4/5
- 2 * RP box with RF shield in 5/6
- 1 * RP cylinder in 4/5
- 1 * RP cylinder in 5/6

J.Varela, CT-PPS Status
Report - March 3, 2015

Update on CT-PPS: Summary

- Roman Pots are installed & calibrated in the LHC tunnel at ip5
- Collimators TCL4 and TCL6 are installed
- RP Si-strip detectors & electronics successfully tested
- Insertion of horizontal RPs at low β^* under discussion with LHC coordination
- Quartic fabrication and integration in cylindrical Roman Pot under preparation
- Quartic electronics and firmware is under design
- 3D pixel sensors production is in preparation at CNM
- CT-PPS is joining Tracker production of DAQ boards (uTCA)
- Beam tests scheduled at Fermilab & CERN SPS
- Active R&D is several fronts
- Installation of new components in tunnel (FE electronics/clock/DAQ) needs to be specified and summarized in addendum to ECR upgrade

J.Varela, CT-PPS Status
Report - March 3, 2015

Publications (updates since last LHCC)

Selected highlights of 2014 in *New J. Phys.*:

- “LHC optics determination with proton tracks measured in the Roman Pots detectors of the TOTEM experiment”, *New J. Phys.* **16** 045018

Accepted for publication:

- “Measurement of the forward charged particle pseudorapidity density in pp collisions at $\sqrt{s} = 8$ TeV using a displaced interaction point” in *Eur. Phys. J. C*

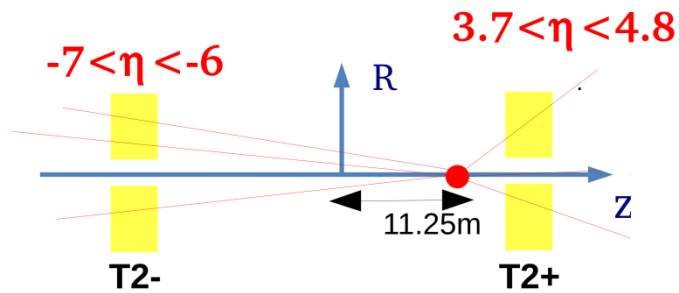
To be submitted (editorial process being finalized):

- “Evidence for non-exponential elastic proton-proton differential cross-section at low $|t|$ and $\sqrt{s} = 8$ TeV by TOTEM”

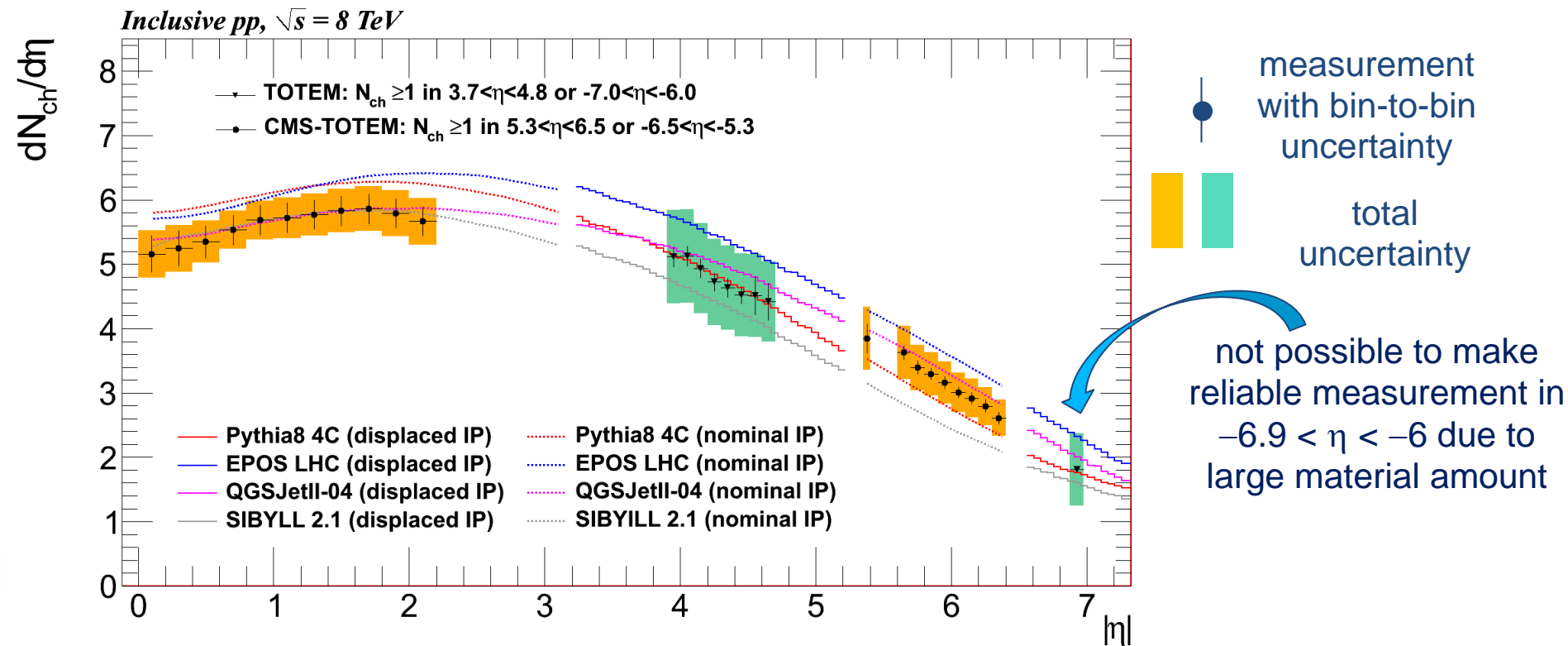
In preparation:

- paper on Coulomb-hadronic interference in elastic scattering at $\sqrt{s} = 8$ TeV
- note on low mass resonances in DPE (together with CMS)

Forward charged particle pseudorapidity density using a displaced interaction point



Accepted by
Eur. Phys. J. C



Evidence for non-exponential elastic proton-proton differential cross-section at low $|t|$ and $\sqrt{s} = 8$ TeV

To be submitted
for publication

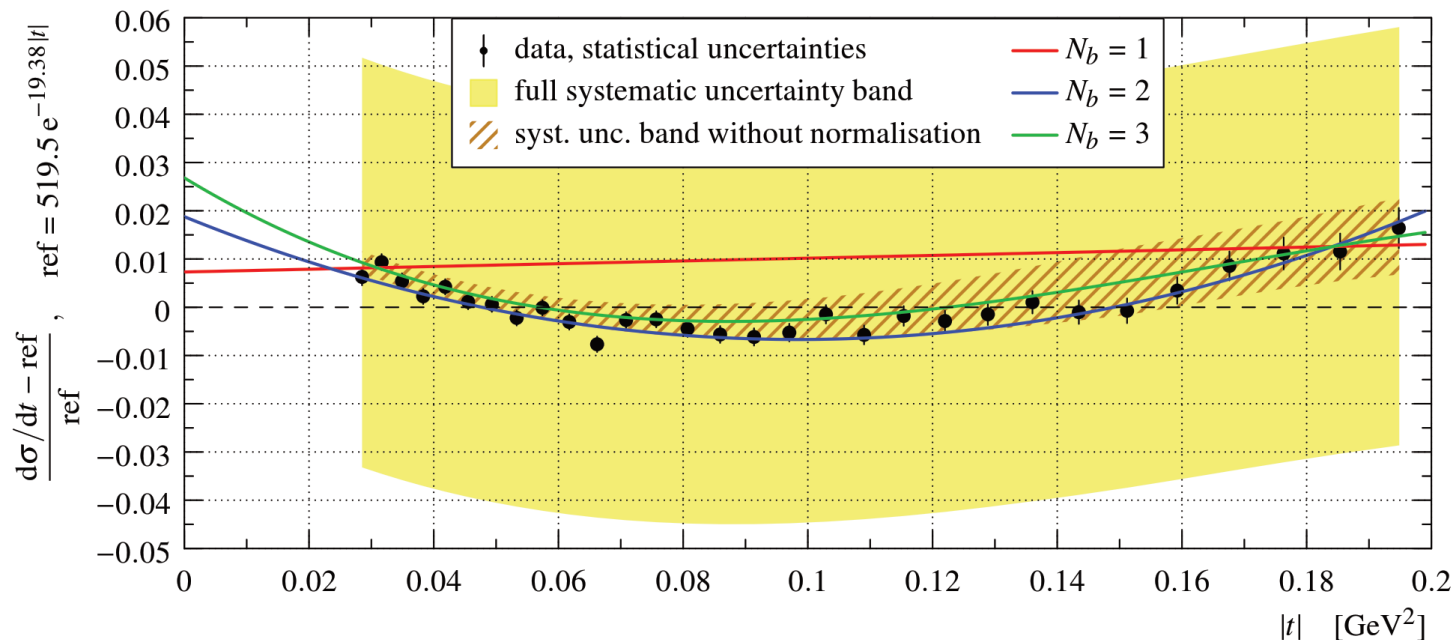
$$d\sigma/dt \propto |F^{C+H}|^2 = \text{Coulomb} + \text{hadronic} + \text{“interference”}$$

from
QED

constrained by measured $e^{-B(t)}$
 $B(t) = b_1 t + b_2 t^2 + \dots$
 $N_b = \#$ parameters in exp.

Simplified West-Yennie (SWY) [1]: often used “standard”, only compatible with pure exponential amplitude & constant phase
 [1] G. B. West and D. R. Yennie, Phys. Rev. 172 (1968) 1413.

Exclude Coulomb-hadronic interference with constant phase & constant exponential slope for hadronic amplitude ($N_b = 1$) at $>7\sigma$ using same data \Rightarrow **ruling out SWY approach**



Conclusions

- Commissioning of the Roman Pots movement and interlock system ongoing
- T2 is installed, three quarters are operational, one will be repaired
- T1 is being installed
- Timing detector for Vertical RPs is close to final design
- The full TOTEM Apparatus commissioning is progressing smoothly and expected to be ready to exploit the earliest LHC's beams:
 - LHCf and/or VdM fills in May 2015
 - TOTEM special Physics run in Sep 2015
- CT-PPS: Qualify new horizontal pots with cylindrical shape and pots with RF shields by means of insertion exercises



Thank you